TEACHWITHPORTALS™

Subject: Math

Title: Introduction to Parabolas with the Puzzle Maker

Author:

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School / Organization, City and State / Province:

Shoreline, WA

Grade Levels: 8 or 9

Common Core Standards Met:

High School:

Construct and compare linear, quadratic, and exponential models and solve problems.

- F-LE.1. Distinguish between situations that can be modeled with linear functions and with exponential functions.

Analyze functions using different representations.

- F-IF.7. Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.★
    - a. Graph linear and quadratic functions and show intercepts, maxima, and minima.

Time needed for lesson: One class period

Overarching Question and Objectives:

What is a parabola and where might we see one?

- Students will be able to explain how a quadratic function differs from a linear function
- Students will be able to identify and explain key vocabulary associated with parabolas
- Students will be able to demonstrate how to find a minimum and maximum vertex

Summary of lesson:

The purpose of this lesson is to get students thinking about the difference between linear and quadratic functions. The beauty of the Puzzle maker in this lesson is that students get to "experience" the parabolic motion they design. The lesson begins with an investigation of things both linear and quadratic in nature within the Puzzle Maker. Students then experiment with the aerial faith plates to manipulate the vertex of the parabola and try to find different ways to represent parabolic motion. This lesson serves as a great intro to parabolas before students begin graphing $y = ax^2$.

Vocabulary:

Parabola – the U-shaped, curved graph that is the result of graphing a quadratic function

Axis of symmetry – the line that divides the parabola into two identical halves

Vertex – the highest or lowest points on a parabola

Minimum – If the parabola opens upward, the vertex is at this point, the lowest point

Maximum – If the parabola opens downward, the vertex is at this point, the highest point

Teacher materials needed:

If possible, a computer that will allow you to project the Puzzle Maker for class discussion purposes.

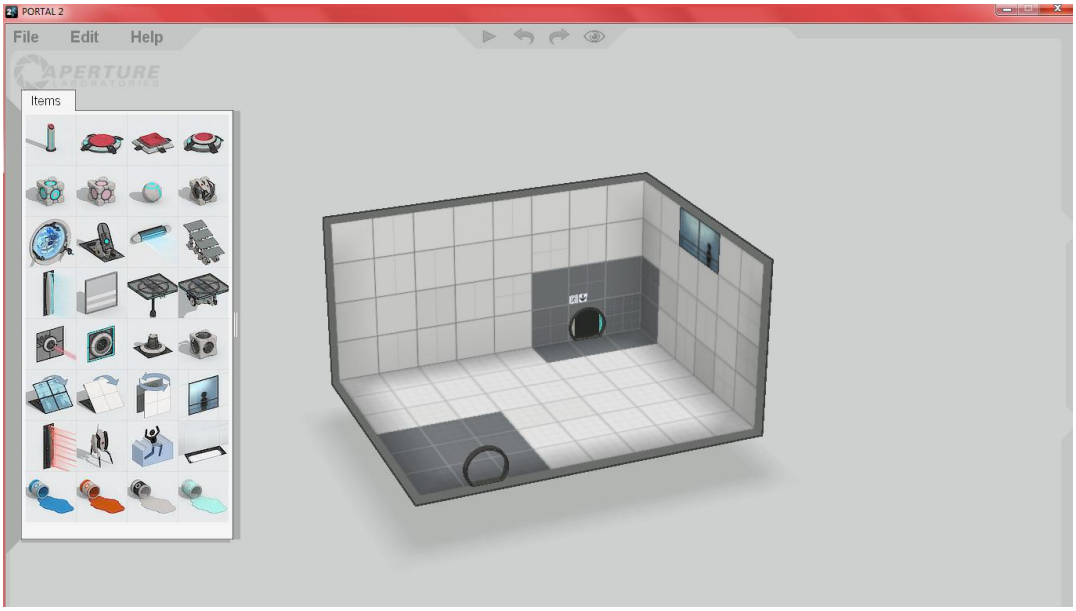
Student materials needed:

* The Puzzle Maker
* Graph paper and pencil or graphing calculator

Lesson Plan:

Briefly introduce students to the concept of the Puzzle Maker. Show them the initial test chamber as well as the item panel of objects they can add to the room. Give them some time to play around with the various objects. However, they have a purpose behind their play…they are to try and find examples of things that have a constant rate of change (or linear motion) and

things that seem to not have that kind of motion. They should jot down as many examples as they can come up with of both types for further discussion after the exploration period.



Encourage students to work together and discuss the objects they are exploring—especially once they build the rooms. That way they really get to experience the various items firsthand.

Once students have had sufficient time to explore the test chamber and related objects, initiate a discussion.

Ask: *Did you find anything that seemed to have a linear change to it? Did you find things that had a non-linear change?*

This could also be a great time to re-emphasize that what makes something "linear" is its constant rate of change. Students might say that the propulsion gel seems to drip out at a constant rate. They could point out that their character seems to walk at a constant rate. The cubes seem to fall out at a constant rate. They may not know what any other "type of change" looks like, and that's just fine. That's what we will explore in this lesson. If they do point things out (such as, you don't come out of a portal in a straight line) then acknowledge their observation but don't elaborate too much at this point.

Using the Puzzle Maker, design a basic room that has an aerial faith plate with a target (while students observe). Point out the parabola with the white-dotted lines that shows up as you manipulate the placement of the faith plate.

Ask: *Does this path represent a straight line? (No, it does not!) Do any of you know what we call this type of shape? (Parabola) A "parabola" is the result of an equation where "x" is squared. In our linear equations, x was never raised to a power.*

Parabola resulting from the placement of the aerial faith plate.

Ask students to go to a new chamber and ask them to place an aerial faith plate in the room and to play around with the target. Ask: *What do you notice about the shape of the parabola as you move the target around?*

Explain that you are going to introduce some common vocabulary that we can all use as we discuss parabolas. Restate the definition of parabola, and explain axis of symmetry, vertex and maximum with students.

If students have not discovered the little yellow dot that sits at the vertex of the parabola, show them that they can manipulate the vertex of the parabola by dragging that dot up or down. Encourage them to create a parabola with a very high maximum, and try it in the play mode, and then one with a very low maximum in the play mode so they get a sense of the difference in motion.

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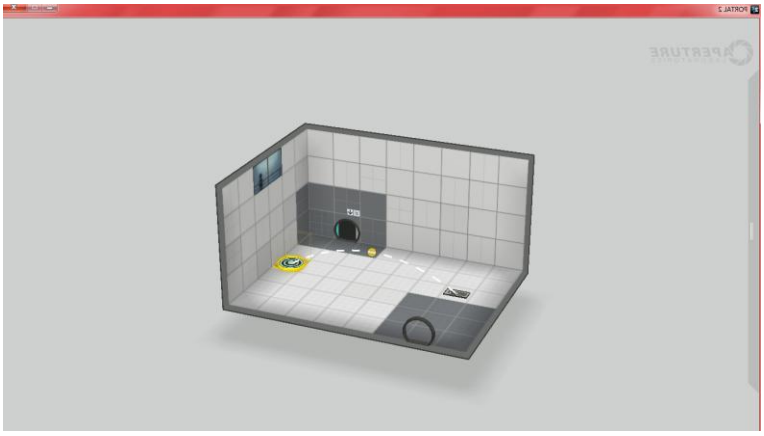

Ask: *What other things, in real life, travel in a parabolic path with a maximum?* Students may come up some examples such as soccer balls, roller coasters, a person diving off of a diving board, etc.

Draw their attention to the fact that the parabola maintains its symmetry even when they manipulate the vertex point. Encourage them to think about why this might be (because x is squared).

Explain that one of the main premises behind the Puzzle Maker is the ability to use portals (if students don't already know this). Demonstrate how to make portals and then have students build a simple chamber and have them experiment with traveling through the portals.
Ask: *When you jump through a portal is the motion linear? Prove your answer.*

(Students should demonstrate that the motion is not linear. They could do this by dropping an object through the portal so we can observe it falling or simply by jumping through the portal and pointing out that they land several cubic units away from the wall with portal and do not drop straight down.)

Tell students: *When we are graphing parabolas we are working with functions in the form* $y = ax^2 + bx + c$. *What we are manipulating right now is the "a" term. The "*x^2*" is what gives the parabola its curved shape. The "a" term changes the width and direction of the parabola. Which parabola do you think is wider, one with an "a" term of 4 or one with an "a" term of ¼?*

You can have students graph by hand or using graphing calculators to experiment and find out that ¼ is much wider.

Point out that both of those parabolas open upwards, however, so the vertex is a "minimum." Both of those parabolas had a positive "a" term and a minimum. If the parabolas open downwards, and have a maximum, is the "a" term positive or negative?

Students can experiment a bit with various "a" terms on their calculators to see what effect the size of the integer has on the parabola's shape.

Explain to students that their next challenge is to see if they can find a way to model a parabola (or even a section of a parabola) that has a minimum instead of a maximum with the Puzzle Maker.

Students may come up with something such as this. They might drop a section of the floor down, put an aerial faith plate at the bottom of the floor in the center with the target up on one wall. If they then shoot a portal across from the target, bounce down on the aerial faith plate to then bounce up to hit the target, they have a pretty good model of a parabola with a minimum.

To wrap up the lesson, have students complete a brief exit slip highlighting three important things they learned about parabolas today in class. This will help to give you a sense of what they took away from the lesson.

At this point students have had an opportunity to really explore and actually "try out" their parabolas. This will help to provide a strong foundation (and mental imagery for them) as they begin their work with quadratics. When I used this lesson I gave homework from their

traditional book from the introductory section on parabolas to reemphasize the key-points we discussed in the lesson.